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HIGHLIGHTING THE HISTORY OF FRENCH RADIO ASTRONOMY. 1: NORDMANN'S ATTEMPT TO OBSERVE SOLAR RADIO EMISSION IN 1901

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Abstract: Soon after the discovery of radio waves by Hertz in 1888 the idea that the Sun must emit this radiation was suggested. A number of scientists from different nations then attempted to detect this emission, and one of these was the French astronomer, Charles Nordmann. This paper provides biographical information on Nordmann before discussing his attempt to detect solar emisson in 1901 and the reasons he was unsuccessful.

Keywords: solar radio emission, Charles Nordmann, Johannes Wilsing, Julius Scheiner, Sir Oliver Lodge.

1. INTRODUCTION

The founding of radio astronomy is conventionally traced back to the pioneering efforts of Jansky and Reber during the 1930s (see Kellermann, 2005; Sullivan, 1984), but Woody Sullivan (1982: 141) is quick to remind us that the idea that the Sun emits radio waves emerged soon after 'hertzian waves' were discovered. During the critical decade from 1891 to 1901 a number of different scientists attempted to detect solar radio emission. One of these was the French astronomer, Charles Nordmann, and this short paper provides biographical material about him before critically examining the ambitious research project that he mounted in 1901.[1]

2. CHARLES NORDMANN: A BRIEF BIOGRAPHICAL SKETCH

Charles Nordmann (Figure 1) was born in Saint-Imier, Switzerland, on 18 May 1881 (Esclangon, 1941), but moved to France early in life, both of his parents being of French extraction (for localities mentioned in the text see Figure 2). We know nothing about his schooling, but in 1899 he received his 'Licence ès sciences',[2] and the following year he accepted an honorary position at Meudon Observatory in Paris (Nordmann, 1911).

Obviously Nordmann was totally committed to astronomy, for June 1902 saw him appointed as an astronomer at Nice Observatory, heading the Magnetic Service. Being interested in solar astronomy, he was able to carry out a variety of investigations in this field (e.g. on the periodicity of sunspots, the solar corona, geomagnetism, possible solar effects on the compass, and the *aurora borealis*). In 1903, soon after turning 22 years of age, Nordmann was awarded the title of Docteur ès Sciences for his thesis *Essay on the Role of Hertzian [=Radio] Waves in Physical Astronomy and on Various Related Issues* (Nordmann, 1903). This also reflected his solar focus, but went even further by announcing his interest in the possibility of radio emission from celestial bodies. We will return to this topic in Section 3.

While there is no definite evidence of this, Nordmann may not have been happy at Nice Observatory, for in July 1903 we find him based at Paris Observatory working in an honorary capacity whilst retaining his Nice appointment (Loewy, 1904). He continued in this same vein the following year (Loewy, 1905), but must have subsequently severed links with Nice for in 1905 he was appointed by the Bureau of Longitudes to lead a solar eclipse expedition to northern Africa. He then showed that he was only too willing to expand his solar horizons by carrying out geomagnetic mapping of Algeria and Tunisia (Nordmann, 1911).

Figure 1: Charles Nordmann (1881–1940), (after Berget and Rudaux, 1923: 242; Françoise Launay Collection).

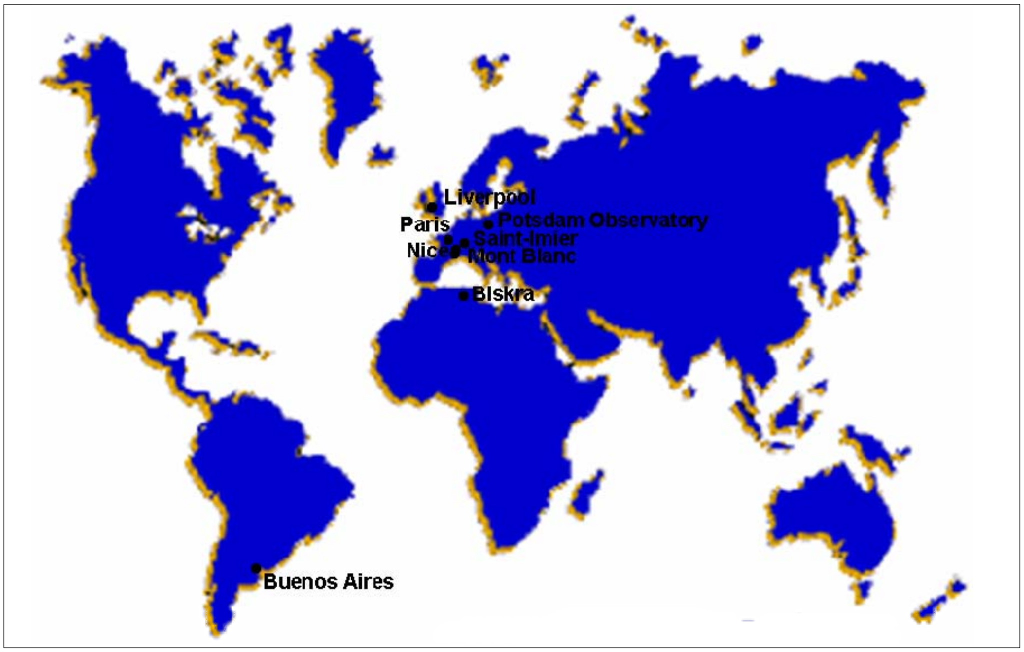

Figure 2: Localities mentioned in the text (outline map courtesy of www.theodora.com/maps, used with permission).

Later in 1905, after returning from Africa, Nordmann finally joined the staff of Paris Observatory in an official capacity, as an astronomer (Loewy, 1906), and he continued to work there until 1940 (Esclangon, 1941). Soon after starting at Paris Observatory he had to quickly broaden his research portfolio, so that he could head a mission to Biskra (Algeria) in 1907 and carry out stellar photometry (Nordmann, 1911). His publications over the next five years included papers on such diverse topics as atmospheric physics, terrestrial magnetism, Comet 1P/Halley, variable star research, stellar photometry, stellar physics, stellar parallaxes and even the dispersion of light in interstellar space, and these were published in a variety of journals, including *Astronomische Nachrichten*, *Comptes Rendus de l'Académie des Sciences*, *Revue Générale des Sciences* and *Terrestrial Magnetism and Atmospheric Electricity* (Nordmann, 1911). The lists of research papers by staff included in the various Paris Observatory *Annual Reports* confirm that Nordmann was an active researcher and a prodigious publisher.

Nordmann served with distinction during the First World War, and at the end of hostilities returned to Paris Observatory, where he then proceeded to devote much of his time to research in stellar photometry. For this he assembled his own 3-colour liquid filters, which he attached to a modified Zöllner photometer.[3] This instrument was used with the Observatory's 27-cm 'Petit coudé' telescope (which was destroyed at the beginning of the 1970s).[4] It is interesting that Nordmann's work is discussed on no fewer than seven different pages in Hearnshaw's (1996) authoritative history of astronomical photometry.

During his lifetime, Nordmann organised various conferences, and he received a variety of honours and awards. In 1907 and 1908 he was a laureate of the French Academy of Sciences, and in 1912 was appointed *Chevalier de la Légion d'honneur*. The previous year he had become a Professor at the School of Clockmaking and Mechanical Precision. In 1920 he was promoted to the post of *Astronome titulaire* (Senior Astronomer) at Paris Observatory, and in December of that year received the Prize of the Academy of Sciences for his research on stellar photometry. In 1928 he ventured abroad to deliver a course on astrophysics at the University of Buenos Aires in Argentina (Nordmann, 1928).

Charles Nordmann died prematurely on 28 August 1940 after a long and difficult illness (Esclangon, 1941); he was just 59 years of age.

Figure 3: Henri Deslandres, 1853–1948 (after Berget and Rudaux, 1923: 63; Françoise Launay Collection).

3. NORDMANN'S ATTEMPT TO DETECT SOLAR RADIO EMISSION

Henri Deslandres (Figure 3) was probably the first French astronomer to think about the emission of radio waves from the Sun. In 1889 Deslandres joined the staff of Paris Observatory specifically in order to develop astrophysics, which was a rather new field of research in France at the time (see Débarbat et al., 1990; Véron, 2005). He worked at Paris Observatory until 1897, when he transferred to Meudon Observatory (Michard, 1971). In about 1900, Deslandres became aware that the Sun could emit radio waves (see Deslandres and Décombe, 1902), and it is not unreasonable to suppose that he discussed this matter with Nordmann when they met.

Be that as it may, on 19 September 1901 Nordmann carried out a carefully-planned attempt to detect radio emission at hectometric wavelengths (i.e. at a frequency in the range 0.3–3 MHz) from a 3,100 m site at Grands-Mulets, on the slopes of Mont Blanc, in the Alps (see Figure 2). His reasoning in selecting this site is interesting. Although atmospheric absorption is actually negligible at this wavelength,

> The choice of an elevated site for this research was definitely indicated since it eliminated to the largest extent possible the absorbing action of the atmosphere and above all water vapour on the hypothetical [radio] waves ... (Nordmann, 1902a: 273; our translation).

Nordmann and his assistant, an electrical engineer by the name of F. Haberkorn (Nordmann, 1902a: 275),[5] set up their 175 m long antenna (which was mostly sensitive to wavelengths between 100 and 1,000 m) on the surface of the Bossons Glacier, supported at intervals by wooden posts. The antenna was obviously oriented N-S, so that "… towards midday the solar rays were normal to it." (Nordmann, 1902a: 273). Furthermore,

> The choice of a glacier to support the antenna was a very important one ... The glacier can, in effect, be considered a near-perfect isolator… which at the same time is transparent to radio waves; furthermore, another reason is that the thickness of the ice at the place where we erected the antenna (on the basis of crevasses that we found) was estimated to be at least 25 m and the solar rays were, at the time of our experiments (the summer equinox), very inclined from the vertical, so there would be little error caused by interference between solar rays received directly and those reflected by the underlying ground surface onto the aerial. (Nordmann, 1902a: 273-274; our translation).

However the statement that the glacier can be considered as a 'near-perfect isolator' is wrong, and the reflector was only a small fraction of a wavelength below the antenna wire. In this condition the beam maximum was approximately at right angle to the wire, a favorable position since the Bossons Glacier was roughly perpendicular to the Sun's elevation at transit at the date of the observation. The antenna was not tapped to a tund circuit and accepted a broad range of frequencies, with the sensitivity and to some extent the beam direction dependent upon frequency.

The receiver developed by Nordmann and Haberkorn consisted of a Branly 'radioconductor',[6] immersed in a vessel containing mercury in order to protect this detector from 'external Hertzian waves' (see Figure 4). The antenna was connected to the radioconductor, and an insulated wire, F_1, led from the radioconductor to a galvanometer and a battery. A non-insulated wire, F_2, completed the circuit by linking the battery to the mercury. Two different equally-sensitive radioconductors were used for the solar experiments: one consisted of nickel filings and the other of 30 small steel balls in mutual contract. It was expected that the resistance of these radioconductors would change if solar radio emission was detected, and this would be revealed by deflections of the galvanometer needle.

On 19 September Nordmann and Haberkorn observed the Sun throughout the day, and although the weather was beautiful and the sky was cloudless they did not detect any solar radio emission. Nordmann (1902a: 275; our translation) concluded that

> ... the Sun does not emit electromagnetic radiation at long wavelengths that are capable of making an impression on our radio receivers, or that if it does emit such radiation this is completely absorbed by the solar atmosphere and the upper regions of the Earth's atmosphere.

Nordmann (1902a) reported the results of this investigation in a 3-page paper titled "Recherche des ondes hertziennes émanées du Soleil." (i.e. "Research on radio waves emanating from the Sun"), which was published in *Comptes Rendus de l'Académie des Sciences* in 1902, and this immediately inspired Deslandres and Décombe to assemble a paper on the topic, which appeared in the same journal later that same year.

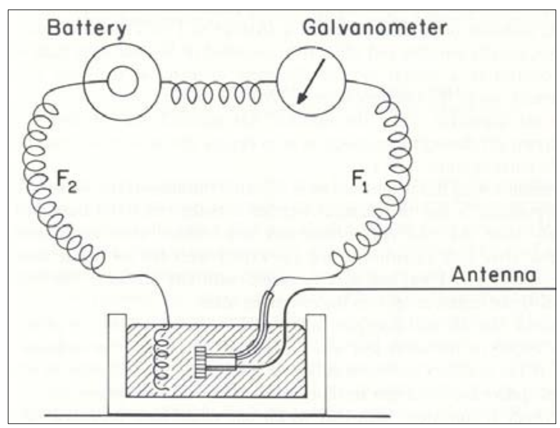

Figure 4: The radio receiver used by Nordmann and Haberkorn at the Bossons Glacier, Mont Blanc, in September 1901 (after Sullivan, 1982: 159; cf. Nordmann, 1902a: 274).

The Deslandres and Décombe paper starts by pointing out that the search for solar radio emission has been in progress since 1895, and that "The Earth does not continuously receive detectable [solar] radio emission, at wavelengths similar to those used in telegraphy (i.e. between 10m and 1000m)." (Deslandres and Décombe, 1902: 528; our translation). The authors then mention attempts made by Wilsing and Scheiner to detect solar radio emission between 1896 and 1899 and Nordmann's recent paper, and make the point that "This negative result is less surprising if one notes that, here on Earth, incandescent substances that emit light and heat do not normally emit radio waves." (ibid). However, the authors suggest that the chromosphere and prominences emit radio waves through a mechanism that is comparable to the electrical discharges that occur in the Earth's atmosphere, and although much of this emission is absorbed by the solar and terrestrial atmospheres it is quite likely that a small percentage of this radiation does in fact reach the surface of the Earth. Deslandres and Décombe (1902: 529) then discuss eruptive prominences and postulate that they are associated with long-wave radio emission that causes storms here on Earth and disrupts telegraphic communication. And with considerable optimism—we might add—they suggest that the study of solar radio emission will eventually become the domain of regular solar astronomers. Finally, they conclude with the prophetic statement: "… a long series of observations will be necessary in order to finally decide if the surface of the Earth does receive radio emission from the Sun." (Deslandres and Décombe, 1902: 530; our translation).

Immediately following this paper by Deslandres and Décombe is a second paper by Nordmann (1902b) which elaborates on his earlier contribution and—as the title suggests—discusses a variety of celestial phenomena that may be explained by invoking radio emission.[7] But first, Nordmann (1902b: 530; our translation) begins by discussing his Mont Blanc result:

> The negative nature of the result that I obtained in the course of carrying out the experiments on Mont Blanc and which I outlined in a recent note to the Academy can be explained by the fact that the solar electromagnetic radiation was entirely absorbed by the upper rarified regions of the Earth's atmosphere.

This is a particularly perceptive comment, for it anticipates by several decades our current thinking on solar radiation and its penetration of the terrestrial atmosphere at different wavelengths.

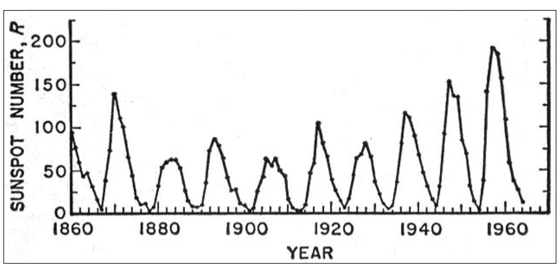

Figure 5: Zurich sunspot numbers between 1860 and 1960 (adapted from Smith, 1967: 28). Note that Nordmann's 1901 observations were made at sunspot minimum.

Nordmann then discusses spectral studies of the chromosphere and prominences, and suggests that the extremely intense electrical discharges with which they are associated undoubtedly also generate radio waves. More specifically:

> The surface of the Sun must emit radio waves, and this emission must be particularly intense from those regions where violent eruptions occur and at periods when these eruptions are at a maximum, that is to say from regions with sunspots and faculae at times of maximum solar activity. (Nordmann, 1902b: 531; our translation).

From here, Nordmann proceeds to discuss the solar corona, the way in which its form changes in the course of the solar cycle, and its association with solar radio emission:

> The physical agent which makes the coronal gases incandescent is of electrical origin: these gases are illuminated by solar radio waves that conform the to known properties of such emission, and the [coronal] illumination is most intense during sunspot maximum, precisely at the time when this emission is at its greatest intensity. (Nordmann, 1902b: 532; our translation).

Nordmann then briefly turns his attention to comets, and suggests that radio waves are responsible for the luminescence of gases in the tails of different comets. This brings his 3-page paper to a end.

In 1903 Nordmann submitted his Doctoral thesis to the University of Paris, and its title—*Essai Sur le Rôle des Ondes Hertziennnes en Astronomie Physique et sur Diverses Questions qui s'y Rattachent*—suggests that we might expect new material on solar radio emission to be included. However, this proves not to be the case: unfortunately, only the contents of his two 1902 papers are reproduced.

From this point, Nordmann's solar investigations remained pretty much forgotten until the early 1950s when they were noted by the Institute of Astrophysics astronomer, M. Laffineur (1952), in his doctoral thesis, but it was only in 1967 that they received international exposure when Alex Smith (1967) mentioned them in his book, *Radio Exploration of the Sun*. Woody Sullivan took Nordmann's work to an even wider audience in 1982 when he included English translations of Nordmann's first 1902 paper and the follow-up paper by Deslandres and Décombe in his *Classics in Radio Astronomy*. Sullivan (1982: 145) described Nordmann's Mont Blanc project as "… a remarkable experiment …"

In spite of Sullivan's publicity, Nordmann's work is little known to present-day astronomers.

4. DISCUSSION

Why was Nordmann's 1901 experiment unsuccessful? There are a number of factors to consider. Even at the very long wavelengths at which he chose to operate, solar bursts of spectral types III and occasionally II do occur (and can be observed from space), but they are rare during the solar minimum, which just happened to coincide with when Nordmann made his observations (see Figure 5). On the other hand, 0.3-3 MHz radio waves are reflected by the Earth's ionosphere at intermediate latitudes, and only stand a chance of penetrating through to the Earth's surface when solar activity is minimal and at special locations (such as Tasmania). Despite his own misgivings, the receiver that Nordmann (1902b) used probably did have the sensitivity to detect energetic solar bursts. Sullivan (1982: 146) believes—perhaps somewhat optimistically—that Nordmann was unlucky: "If it had not been a time of solar minimum or if he had been persistent enough to observe for more than one day, he might well have succeeded and thereby drastically changed the history of astronomy." To the contrary, we feel that Nordmann had no chance of detecting solar radio bursts, because of the inappropriate wavelength range that he selected.

As we have seen, Nordmann's Mont Blanc investigation was partly inspired by Wilsing and Scheiner's unsuccessful attempt to detect solar radio emission in 1896. Johannes Wilsing (1856–1943) and Julius Scheiner (1858–1913) were two well-known astrophysicists from the Potsdam Observatory, and they attempted to observe solar radiation using the simple 'receiver' shown in Figure 6. Wilsing and Scheiner describe their equipment which, contrary to that of Nordmann, was only sensitive at centimetric and decimetric wavelengths:

> … when choosing a method for the detection of electric solar radiation, the highest possible sensitivity was important. We considered as particularly suitable the method … based on the changes in galvanic resistance, discovered by Herr Lodge [in Liverpool, England], which are initiated by electric oscillations incident on two metals loosely in contact.
>
> … For these experiments we inserted into the circuit of a cell both a multiplier [an old type of galvanometer], whose pair of 6-cm long needles had an oscillation time constant of 10 sec, and a "bridge" sensitive to electric oscillations. The bridge consisted of a steel wire, a few millimeters thick and several centimeters long, which had been loosely laid over two other steel wires of similar dimensions, thus closing the circuit ...
>
> We achieved a complete isolation against … [local interference] only when the bridge, the galvanometer, the cell, and the conducting wires were all enclosed in a box covered with tin foil.
>
> … we had to keep the [radio] waves away from the contact points of the wires without enclosing the galvanometer and the cell in the box … and we achieved this in the following manner. On the upper side of a cube-shaped sheet metal box we cut an opening 100 cm^2 in area through which we could bring the bridge into the box. The opening was then closed again by means of a tight fitting metal lid. From the bridge a conducting wire led to the inside wall of the box at which point on the outside a wire was soldered which led to the cell. The second wire, which connected the bridge with the cell, led from the cell first to the center of a metal plate 25 cm^2 in size and then was insulated as it went to the bridge through a small opening in the side of the box. That side of the box was covered with a thin layer of paper which prevented the passage of current from the above mentioned, tightly fitting metal plate to the box. (Wilsing and Scheiner, 1896; cited in Sullivan, 1982: 148-150).

On eight different days between 23 June and 11 July 1896 Wilsing and Scheiner (Sullivan, 1982: 156) used this device to try and detect solar radio emission:

> … we directed solar rays reflected from the metal mirror of a heliostat towards the box. With the lid of the box removed, the rays then struck the bridge. When the heliostat mirror was covered with black paper, a highly sensntive thermopile at the same location as the bridge exhibited only a small heating effect. This effect could be made entirely imperceptible by inserting a paper screen [between the mirror and the thermopile] ...
>
> First of all, a strong effect, in the sense of a decrease in resistance, was exhibited with the mirror uncovered … [but] these changes continued for a long time after the radiation was stopped ...
>
> In order to measure the resistance changes, we used a Wheatstone bridge connected with a Siemens galvanometer whose bell-shaped magnets had been replaced by a lighter system … The movement of the reflected image of the scale, 2 m distant from the galvanometer, was monitored with a telescope. After determining the resistance of the bridge, we measured the sensitivity … by inserting a known small resistance into the same section [of the circuit]. The box was then opened and the effect of the radiation on the resistance observed. Finally, we checked the sensitivity of the bridge by excitation of the spark gap. (Wilsing and Scheiner, 1896; cited in Sullivan, 1982: 154-155).

Wilsing and Scheiner presented their results in a table (see Sullivan, 1982: 156), and concluded that

> These experiments led to no positive results. If we separate the domain of the investigated oscillations from that of the heat radiation by requiring that the oscillations have the ability to an appreciable extent to penetrate a non-conductor, then it has not been possible to measure in these experiments the amount of energy from any such solar radiation. (Wilsing and Scheiner, 1896;cited in Sullivan, 1982: 155).

Having said that, Wilsing and Scheiner (ibid.) caution that "Due to the possible screening effect of our atmosphere … this does not mean that we can deduce the absence [of electrodynamic oscillations] in the original complex of rays emitted by the Sun." In this case, the terrestrial atmosphere does not absorb radio waves, but the small size of the heliostat mirror and of the antenna enormously limited the sensitivity.

At about the same time Wilsing and Scheiner were researching solar radio emission, Sir Oliver Lodge (1851–1940) was carrying out parallel investigations in England. Sir Oliver was a multi-talented scientist, and he writes that some time between 1897 and 1900

> I [hoped] to try for long-wave radiation from the sun, filtering out the ordinary well-known waves by a blackboard or other sufficiently opaque substance. I did not succeed in this, for a sensitive coherer in an outside shed unprotected by the thick walls of a substantial building cannot be kept quiet for long. I found its spot of light liable to frequent weak and occasionally violent excursions, and I could not trace any of these to the influence of the sun. There were evidently too many terrestrial sources of disturbance in a city like Liverpool to make the experiment feasible. I don't know that it might not possibly be successful in some isolated country place; but clearly the arrangement must be highly sensitive in order to succeed. (Lodge, 1900: 33; cited in Sullivan, 1982: 141).

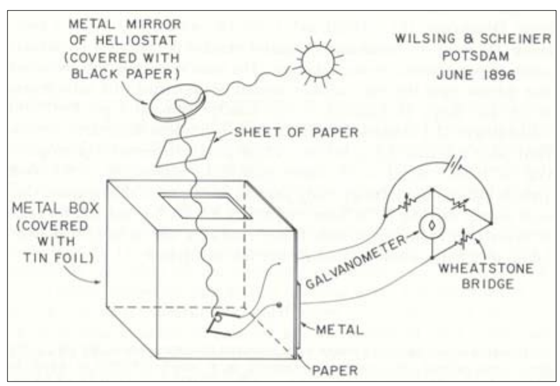

Figure 6: The 'radio receiver' used by Wilsing and Scheiner in 1896 (after Sullivan, 1982: 145).

Let us now return to Nordmann. Despite his unsuccessful attempt to detect solar radio emission, he was convinced that such radiation existed, and on this basis over the next two years he proceeded to write four other research papers about what we would now term 'radio astronomy.' The first of these examined the relevance of radio emission to astrophysics (Nordmann, 1902c), while another paper published in 1902 briefly examined the possible relevance of solar radio emission to aurorae and the magnetic field of the Earth (Nordmann, 1902e). Then in two later papers, Nordmann (1904a; 1904b) expanded considerably on material first presented in some of his 1902 papers and in his 1903 doctoral thesis. One of his conclusions, although plainly wrong, is particularly interesting:

> I think that the aurora borealis is a phenomenon produced in the [Earth's] atmosphere by radio waves emanating from the Sun … (Nordmann, 1902e: 592; our translation).

Nordmann was aware that his 1901 investigation was conducted during sunspot minimum, and he planned to carry out further observations in 1904—when the Sun would be more active. However, this was not to be. From comments he makes in a 1902 paper on nebulae (Nordmann, 1902d) and in his doctoral thesis (Nordmann, 1903), it is obvious that Nordmann did not support some of Deslandres' scientific conclusions, and it is equally clear that this senior French scientist did not enjoy the controversy generated by the young 'upstart' (e.g. see Deslandres, 1902: 1486). The friction between these two men and Deslandres' special interest in solar radio emission might explain why Nordmann never carried out the mooted 1904 investigation, and why he turned to the totally 'neutral' research field of stellar photometry when he joined the staff of Paris Observatory in 1905.

5. CONCLUDING REMARKS

In 1901, Charles Nordmann was the first French astronomer, and one among only a handful of international scientists, to search unsuccessfully for radio emission from the Sun. Although various factors contributed to this negative result, the primary causes were the rarity of burst activity at this time of the solar cycle, his decision to only make observations on just the one day, and above all the very long wavelength at which he chose to search. As it was, it took three more decades before developments in instrumentation saw the launch of radio astronomy, but even then another decade would pass before scientists would detect solar radio emission for the first time. When this did eventually occur, separate independent wartime discoveries were made in Australia, Britain, New Zealand, Norway, and USA (Orchiston, 2005; Orchiston and Slee, 2002; and Sullivan, 1984), and the early pioneering efforts of Nordmann and his contemporaries were long forgotten. France, meanwhile, would only begin to make an international contribution to solar radio astronomy in the late 1940s, after WWII (Denisse, 1984; Orchiston and Steinberg, 2007).

Nordmann was a remarkable scientist, who contributed in many ways to astronomy and geomagnetism (Esclangon, 1940). While his premature foray into solar radio astronomy in 1901 is what primarily concerns us here, others will remember him for the important contributions he made to stellar photometry, while those who research Algol variables will undoubtedly recall the Tikhov-Nordmann Effect (see Hearnshaw, 1996: 371-373; Kulikovsky, 1976: 408-409).

6. NOTES

1. This is the first in a series of research papers documenting the early development of French radio astronomy. The second paper in this series is in this same issue of *JAH*², and deals with radio observations made during a series of solar eclipses in the 1940s and 1950s (see Orchiston and Steinberg, 2007).
2. In today's terminology, this would probably be the equivalent of a Bachelor of Science degree.
3. For a description of the Zöllner photometer see Hearnshaw (2000) and Staubermann et. al. (2000). For a diagram of Nordmann's photometer see Hearn-shaw (1996: 102).
4. The 'Petit coudé', which was built in 1882, should not be confused with Paris Observatory's much better-known 'Grand coudé' (completed in 1890), which had an aperture of 60 cm. 'Coudé' comes from the word *coude* (elbow, in English). This type of instrument is mounted equatorially, with the tube comprising two components at right angles to one another.
5. Unfortunately, we were unable to assemble any biographical material about the mysterious Mr Haberkorn.
6. Édouard Branly (1844–1940) discovered in 1890 that an imperfect contact between metallic substances covered by a very thin oxide layer strongly loses its resistance to electricity when submitted to radio waves (Branly, 1890). The resistance is restored by a shock. He called this imperfect contact *radioconducteur*, but in 1894 Sir Oliver Lodge coined the term *coherer* for it. The corresponding set-up, made generally of iron filings and completed by a mechanical striker to re-store its resistance after captation of the radio signal, was used for several years for wireless telecommunication experiments in Morse language by Lodge, Alexander Popov (1859–1906) and Branly himself. The theory of the Branly coherer is only now beginning to be understood (see Falcon and Castaing, 2005).
7. Given that the two radio receivers were critical to the whole experiment, it is interesting that Nordmann chose not to include Haberkorn as a co-author—at least of the initial paper.

7. ACKNOWLEDGEMENTS

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